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TRADE AND DEVELOPMENT BOARD
Standing Committee on Commodities
Intergovernmental Group of Experts on Tungsten
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Geneva, 7 December 1992
Item 5 of the provisional agenda

CONSIDERATION OF PROJECT PROPOSALS BY GOVERNMENTS AND INDUSTRY WHICH COULD BE SUBMITTED FOR POSSIBLE FINANCING UNDER THE SECOND ACCOUNT OF THE COMMON FUND FOR COMMODITIES

Project proposals submitted to the UNCTAD secretariat
by the People's Republic of China

Note by the UNCTAD secretariat

The attached document is circulated by the UNCTAD secretariat at the request of the Permanent Mission of the People's Republic of China. It contains the revised material which takes into account suggestions made by delegations on the three Chinese project proposals at the Ad Hoc Meeting on Tungsten held on 2-3 July 1992.

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GE.92-53046

The UNCTAD Committee on Tungsten hereby submits the following project proposals with its recommendation for financing through the Second Account of the Common Fund.

TITLE OF THE PROJECTS:

(A) Development of the ultra fine-grained WC and cemented carbide

(B) Development of the rare earth doped cemented carbide and its mechanism research

(C) Development of the new process for heat-treatment of cemented carbide and its application

DURATION: Five years

LOCATION: Zhuzhou Cemented Carbide Industry Co.,China

NATURE: Development of new grades of cemented carbide so as to increase their performance and reduce production cost, to improve product structure, to strengthen their ability to compete with substitute materials, and to expand the application field of tungsten.

TOTAL COST: USD 5,080,000
SDR 3,628,572 (Basis 1 SDR = USD 1.4)

FINANCING (AS GRANT)
SOUGHT FROM THE FUND: USD 3,860,000 (SDR 2,757,143)
Project A: USD 1,700,000
Project B: USD 860,000
Project C: USD 1,300,000

COUNTERPART CONTRIBUTION
FROM CHINA: USD 1,220,000 (SDR 871,429)
In cash: USD 410,000
In kind: USD 810,000
Project A: USD 665,000
Project B: USD 330,000
Project C: USD 225,000

PROJECT EXECUTING AGENCY: China National Nonferrous Metals Industry Corp.

ESTIMATED STARTING DATE: As soon as possible

The UNCTAD Committee on Tungsten hereby submits the following project proposals with its recommendation for financing through the Second Account of the Common Fund.

TITLE OF THE PROJECT: (A) Development of the ultra fine-grained WC and cemented carbide

DURATION: Five years

LOCATION: Zhuzhou Cemented Carbide Industry Co., China

NATURE: This project is aimed at adjusting the product structure and expanding application field of tungsten. It is beneficial for international tungsten industry to develop new highly tough cemented carbide for use under slow cutting speed.

TOTAL COST: USD 2,365,000
SDR 1,689,286 (Basis 1 SDR = USD 1.4)

FINANCING (AS GRANT)
SOUGHT FROM THE FUND USD 1,700,000

COUNTERPART CONTRIBUTION
FROM CHINA: USD 665,000

PROJECT EXECUTING AGENCY: China National Nonferrous Metals Industry Corp.

ESTIMATED STARTING DATE: As soon as possible

A. Project description:

With the rapid growth of world economy,it is required that the tool materials should have good TRS, high shock resistance and toughness in addition to high hardness.The ultra fine-grained cemented carbide with a combination of the above properties has obtained a wide application in information industry. As the ultra fine-grained cemented carbide cutting tools can be used in either slow or medium cutting speed under heavy load condition, they are excellent tool materials for filling the gap between high speed steel and cemented carbide.

Since 1970s, great efforts have been made in the world to develop ultra fine-grained cemented carbide, there are some achievements in this field. In 1989, Japan promulgated the first standard for ultra fine-grained cemented carbide (JISB 4053-1989). However, the grain size of WC used is 0.3-0.8 micrometer, while the grain size of WC in cemented carbide is 0.6 micrometer. Due to the comparatively large grain size,the combination of toughness and wear resistance is not adequately satisfactory with the maximum TRS of 3000 N/mm^2 and average TRS of 2000 N/mm^2.

According to results of latest research,the strength and hardness of cemented carbide can be effectively and harmoniously combined without an increase in hardness at the expense of the other or vice versa, provided that the average grain size of WC in cemented carbide is less than 0.3 micrometer. Up to now, there is few ultra fine-grained cemented carbide developed with grain size less than 0.3 micrometer in the world. It is known that the preparation of less than 0.3 micrometer particle size of WC and Co powder is a prerequisite for producing 0.3 micrometer grain-sized cemented carbide.

Main components of the project:

(i) Objectives:

The overall objective of this project is to adjust product structure (Annex 1), and develop ultra fine-grained cemented carbides.

(ii) The strategy and target beneficiaries:
The main strategy is to expand the use of cemented carbide in special machining and electronics industry,such as tools for cutting high temperature alloys and mini-drill for printed circuit board. The achievement report will be delivered free of charge to the interested member countries.

(iii) Expected situation at the completion of the project:
Ultra fine-grained cemented carbide with average WC grain size < 0.3 micrometer will be developed at the end of the project.

(iv) The implementation arrangement:
During the next month following the approval of the project, the Ministry of Foreign Economic Relations and Trade of China and China National Non-ferrous Metals Industry Corp. together with Zhuzhou Cemented Carbide Industry Co.shall meet to finalize the task, objective and executive plan.

When the task is determined and finalized, the departments and personnel concerned shall, within 6 months, complete organizaltion, practical plan, and literature survey; determine process route; conduct overseas technical exchange.
Detailed schedule and executive plan is listed in the attachment.

B. Project justification.

(a) Economical & financial aspects:
The execution of this project can bring the production of world ultra fine grained cemented carbide up to a higher level with new series of grades. It is predicted that economic return of this project can be increased by 20-30% in China.

(b) .Technical appraisal and feasibility:
It is known that the ultra fine-grained cemented carbide with a good combination of TRS, shock resistance and toughness as well as hardness is an excellent tool material, and is gaining increasing use in special machining industry.

At present, the WC grain size in the ultra fine-grained cemented carbide ranges between 0.4-0.7 micrometer. Efforts have been made in China years ago, and some achievements have been obtained. Now China can produce WC powder with average particle size of 0.5 micrometer, and cemented carbide with WC grain size of 0.7-0.8 micrometer. Satisfactory results have been obtained for use in machining heat-resistant alloys.

In the development of this project, research can also be made in preparing active ultra WC based catalyst for application in petrochemical industry.

(c) Environmental aspects:
The ultra fine powder for this project, due to the protection measures, shall not lead to dust pollution of the environment.

(d) Social & economic aspects:
Research and development at the end-use level appears to be price-sensitive. It seems to have accelerated the substitution of other materials for tungsten during periods of rising prices, such as during the late 1970s and the beginning of the 1980s. The situation has since been reversed with the recent decline of tungsten price. However,despite low price, tungsten appears to be slow to recover the ground lost to the other materials. One reason for explaining the difficulty of tungsten to recover the lost ground is the relative neglect of linking basic R&D to develop new grades of tungsten materials and the applied R&D pursued for their application in

industry at the end-user level. The development of the ultra fine-grained cemented carbide shall facilitate the world cemented carbide industry to open new wider field of application to make up for the lost ground.

(e) Relevance to the Common Fund's objectives,priorities and policy guidlines.This project shall contribute to the expansion of tungsten,the strengthening of its competitiveness with substitute materials.

C. Objectives:

1.1. Objective 1.
Development of colloidal tungsten compound and ultra fine WC, and research on passivation of ultra fine WC and its storing measures.

1.1. Output 1.
Development of WC powder with average particle size ≤ 0.3 micrometer.
1.1.1. Activity 1.
The competent authorities and Zhuzhou Cemented Carbide Industry Co. shall evaluate the production process and the technological route of the ultra fine-grained cemented carbide,and reach an agreement.

1.1.2. Activity 2.
A detailed literature survey and extensive technical exchange shall be conducted so as to work out a rational research plan after analysis and evaluation, covering the development of ultra fine WC powder and its cemented carbide,promotion and application as well as the assessment of the achievements.

1.1.3. Activity 3.
Establishment and perfection of the laboratorial equipment, capable of doing pilot experiment.

1.1.4. Activity 4.
The raw material for the production of ultra fine WC shall be prepared by selection of either chemical precipitation ,colloidal chemistry,addition of activating agent, or organic coumpound of metal tungsten.

1.1.5. Activity 5.
The process parameters for the obtaining of ultra fine WC shall be optimized through selection of way of carburization and equipment.

1.1.6. Activity 6.
Research on the passivation of ultra fine powder and its storing measures.

1.2. Output 2.
Development of WC powder with average particle size ≤ o.2 micrometer.

1.2.1. Activity 1.
Establishment of plasma laboratory through equipment purchase ,installation and running-in.

1.2.2. Activity 2.
Research on the process parameters for producing ultra fine WC powder by

plasma furnace.

1.2.3. Activity 3.
Development of ultra fine WC by means of DC plasma.

1.2.4. Activity 4.
Research on passivation technique for stabilizing ultra fine WC powder.

1.2.5. Activity 5.
Research on special protection technique for storing ultra fine powder.

1.2.6. Activity 6.
Research on preparation process of tungsten compound.

2. Objective 2.
Development of ultra fine-grained cemented carbide

2.1. Output 1.
Development of ultra fine-grained cemented carbide with average grain size $\leq$ 0.5 micrometer, HRA 91.5 and TRS -3000 N/mm^2.

2.1.1. Activity 1.
Selection of preparing process and equipment for the production of mixed ultra fine powders.

2.1.2. Activity 2.
Compaction of mixed ultra fine powders,and selection of compaction method and its equipment.

2.2. Output 2.
Development of ultra fine-grained cemented carbide with average grain size $\leq$ 0.3 micrometer, HRA 92.5 and TRS -3500 N/mm^2.

2.2.1. Activity 1.
Optimization of the process parameters for quick vaccum sintering under low temperature.

2.2.2. Activity 2.
Selection of grain growth inhibitor.

3. Objective 3.
Expansion of the use of WC powder in the refining of petroleum.

3.1. output 1.
Preparation of active ultra fine WC powder.

3.1.1. Activity 1.
Survey of literature, formulation of production process.

3.1.2. Activity 2.
Purchase of equipment and raw materials.

3.1.3. Activity 3.
Execution of the preparation process so as to produce the raw material for active ultra fine WC.

3.1.4. Activity 4.
Production of active ultra fine WC via tungsten raw material.

3.1.5. Activity 5.
Testing of the property of active ultra fine WC powder.

3.2 Output 2.
Application of WC based catalyst in hydrogen-added refining fragmentation of secondary fraction oil.

3.2.1. Activity 1.
Designing of the composition of hydrogen-added based catalyst.

3.2.2. Activity 2.
Trial-production hydrogen- based catalyst

3.2. Activity 3.
Test of the ts of the catalyst tion by chromatographic reaction.

3.2.4. Activity 4.
Determination of catalystic property of hydrogen-added refining or tion in simulation industrial production.

Activity 5.
Determination of the optimium composition of the catalyst.

3.3. Output 3.
Testing method and spesification for the catalystic property of the WC.

3.3.1. Activity 1.
Establishment of the equipment and instrument for testing catalystic property.

3.3.2. Activity 2.
Establishment of method and spesification for determining the catalystic property of WC.

3.3.3. Activity 3.
Testing of the WC based catalystic property.

D. Input.

The inputs required to carry out the project's activities as well as to obtain the specific outputs are given in Annex-A1.

E. Risk.

As the price of cobalt is on the rise recently, it is expected that it may have certain effect on this project. However, in that event, China will put in additional investment to make it up.

F. The project budget.

This project is a rather difficult one from the point technology, as it covers the development of equipment, research on analysis and testing as well as production process and basic theory, so amount of USD 1,700,000 is required to be financed by the Common Fund (see Annex-A2).Additionally, China will invest USD 665,000 to help complete project A (see Annex -A3). For number of days during which the new equipment (with investment from the Common Fund and China) would be in use for execution of the project, see Annex-A4.

G. Provisional work plan:

See Annex-A5.

H. Project management.
Project Executing Agency: China National Non-ferrous Metals Industry Corp.

The sponsoring ICB is willing and able to assume responsibility as a Supervisory Body for the project without charge:

YES _____ NO ___

If not, give alternative proposal:

I. Project monotoring,reporting and evaluation:

This project will be periodically monitored by Committee on Tungsten as per its policies and procedures. The result of the project work will be evaluated annually as per the Committe's evaluation system. Progress report will be prepared at six-monthly intervals, and there will be a final report on the conclusion of the project.

J. Annexes:

Annex 1 Statistics for the export of tungsten concentrate by China betwwen 1987-1991
Annex 2 Inputs By China
Annex-A1 Inputs by Common Fund
Annex-A2 Budget for financing by Common Fund
Annex-A3 Budget for investment by China
Annex-A4 Number of days during which the new equipment would be in use
Annex-A5 Provisional work plan

ON BEHALF OF	NAME/TITLE	SIGNATURE	DATE
(THE ICB)	.....	.....	.....

The UNCTAD Committee on Tungsten hereby submits the following project proposals with its recommendation for finanacing through the Second Account of the Common Fund.

TITLE OF THE PROJECT:	(B) Development of the rare earth doped cemented carbide and its mechanism research
DURATION:	Four years
LOCATION:	Zhuzhou Cemented Carbide Industry Co., China
NATURE:	This project is intended to improve practical properties, and to enhance its ability to compete with substitute materials. It is beneficial to make full use of tungsten resources.
TOTAL COST:	USD 1,190,000 SDR 850,000 (Basis 1 SDR = USD 1.4)
FINANCING (AS GRANT) SOUGHT FROM THE FUND:	USD 860,000
COUNTERPART CONTRIBUTION FROM CHINA:	USD 330,000
PROJECT EXECUTING AGENCY:	China National Nonferrous Metals Industry Corp.
ESTIMATED STARTING DATE:	As soon as possible

A. Project description:

As the WC based cemented carbide is a kind of comparatively expensive material,its scope of application is limited to some extent. The rapid growth of world's economy shall lead to an increase in demand for cemented carbide and development of new application. Therefore it is necessary to look for a way of having a material with better property than the existing traditional cemented carbides while at same time without giving up the potential market of tungsten. The development of rare earth doped cemented carbide can achieve that purpose.

The cemented carbide, when doped with rare earth, will show an increase of TRS by 10-20%, and hardness by 0.5-1 HRA. What's more, it has low porosity and higher wear resistance. So there is important significance in bringing the performance of cemented carbide to full play, in reducing production cost and opening new field of application.

Research on the use of rare earth in cemented carbide was started in early 1960s, and was limited to laboratory rather than mechanism at that time in the world. So far, there is no rare earth doped cemented carbide to the market.

Some achievements have been obtained in China with regard to the use of rare earth in cemented cabide, there are a few grades of such products put into production. In terms of mechanism, it is found out that addition of rare earth element to cemented carbide can improve the physical properties of binding phase and performance of cemented carbide as a whole. It can be predicted that the doping of rear earth shall significantly enhance the service life of cemented carbide. Further research into the effect of rare earth addition on wettability of hard phase and re-enforcing mechanism of binding phase shall be of help in promoting this project to a higher level.

Main components of the project:

(i) Objectives:
The overall objective of this project is to fully utilize tungsten resources, to improve the properties of existing grades with doping of rare earth, and to increase its ability to compete with substitute materials.

(ii) The strategy and target beneficiaries:
The target is to develop rare earth doped cemented carbide for wider use,such as hot working tools or dies,structural parts and wear resistant part under hot environment in addition to its use as cutting inserts. The achievement report will be delivered free of charge to those interested member countries.

(iii) Expected situation at the completion of the project:
On the basis of a slight increase in hardness, the durability of rare earth doped cemented carbide can be doubled with an increase in TRS by 10-20%.

(iv) The implementation arrangement:
The competent authorities and Zhuzhou Cemented Carbide Industry Co. undertaking this project shall evaluate the production process of the development of rare earth doped cemented carbide.

At least there shall be 3 persons who have a good understanding of the progress plan and research direction of this project. In addition, they should be able to conduct technical exchange activities at home and abroad.

Presenting stage research reports on the proper kind of rare earth additives, its doping method and amount.

B. Project justification.

(a) Economical and financial aspects:
As this project is cost effective, and it can enhance the comprehensive properties of the existing cemented carbide grades. It is expected that a 10% increase in economic return can be gained for one ton of cemented carbide doped with rare earth.

(b) Technical appraisal and feasibility:
The research on doping cemented carbide with certain rare earth was initiated in the world as early as 1960s. According to some literature report, addition of a small amount of cerium or mixed rare earth to the binding phase can result in improving the high-temperature and anti-oxidation properties as well as toughness.

Late in 1980s,China has made some progress in the research on application of rare earth in cemented carbide. It was discovered that the rare earth doped cemented carbide had shown some improvement in TRS,high temperature property and durability. When it was put into trial use as cleaning scraper for rubber conveyer, the tool life was significantly improved. So far China has trial-produced ,on a small basis, rare earth doped cemented carbide for domestic use with comparatively good results.

Meanwhile, preliminary research has been made on the microstructure of so doped cemented carbides, and basic theory for the mechanism of strengthening cemented carbide by doping rare earth. It shows that the rare earth can improve the structure of Co binding phase and physical & mechanical property, which eventually leads to an increase in the property and durability of cemented carbide.

(c) There is no detrimental effect to the environment.

(d) Social and economic aspects:
Although the research on doping cemented carbide with rare earth was initiated in 1960s,there is no commercial product in the market yet. this seems to have something to do with the uncertainty of product quality and the re-enforcing mechanism of cemented carbide as well as process control. The implementation of the project shall help make progress in this field so as to benefit all cemented carbide producers.

At present, the total trade volume in the world cemented carbide market is around 5500 tones/year. United States is the biggest importer, EEC comes second. Sweden is the largest exporter, which accounts for more than 50% of the world market. According to incomplete statistics, there are about 50 countries producing cemented carbides with an annual output of 28,000 tones/year.

Comparatively speaking, China is a very small exporter in terms of the value-added cemented carbide product, it only accounts for about 4% of the world market, see ANNEX 2. Prediction for the rare earth doped cemented carbide into the world market is listed below:

	1st year	2nd	3rd	4th	5th
Export (t)	5	10	15	20	25
Market occupancy,%	0.09	0.18	0.27	0.36	0.45

* counted as from after completion of the project

(e) Relevance to the Common Fund's objectives,priorities and policy guidelines. This project is to increase the performance of cemented carbide,to strengthen its competitiveness with substitute materials,and to reduce production cost.

C. Objectives:

The overall objective of this project is to adjust product structure, and to develop rare earth doped cemented carbide so as to improve the property of the existing grades to increase its ability to compete with substitute materials.

1. Objective 1.
Addition of rare earth to the existing grades to develop rare earth doped cemented carbide.

1.1. Output 1.
On the basis of a slight increase in hardness ,the durability of rare earth doped cemented carbide can be doubled with an increase in TRS by 10-20%.

1.1.1. Avtivity 1.
Research on the proper kind of rare earth additive,its doping method and amount.

1.1.2. Activity 2.
Research on the microstructure and wettability of rare earth doped cemented carbide.

1.1.3. Activity 3.
To determine process parameters for pilot experiment, and complete designing of rare earth doped cemented carbide grades.

1.2. Output 2.
To present a report on development and its mechanism research.

1.2.1 Activity 1.
Further research on the re-enforcement mechanism of doping rare earth by utilizing various testing means.

1.3. Output 3.
Development of the analytical and testing method for determining rare earth element.

1.3.1. Activity 1.
Research on the chemical analysis of rare earth element content.

1.3.2. Activity 2.
Research on the form of presence ,morphology and structural characteristics of rare earth in cemented carbide by means of X-ray diffraction,TEM and AEM etc.

2. Objective 2.
Promotion and application of the rare earth doped cemented carbide.

2.1. Output 1.
The increase in tool life of rare earth doped cemented carbide can reduce tool wear, tool exchange time, tool cost; enhance machining efficiency and quality, thus leading to a decrease in machining cost.

2.1.1. Activity 1.
Promotion and application of rare earth doped cemented carbide in machining industry in China.

D. Input.

The inputs required to carry out the project's activities as well as to obtain the specific outputs are given in Annex-B1.

E. Risk.

No risk.

F. The project budget.

This project requires financing of USD 860,000 from the Common Fund, see Annex-B2. Additionally, China will invest USD 330,000 , see Annex-B3.
For number of days during which the new equipment (with investment from the Common Fund and China) would be in use for execution of the project, see Annex-B4.

G. Provisional work plan.

See Annex-B5

H. Project management.

Project Executing Agency: China Natioal Non-ferrous Metals Industry Corp.

The sponsoring ICB is willing and able to assume responsibility as a Supervisory Body for the project without charge:

YES _____ NO ___

If not, give alternative proposal:

I. Project monotoring,reporting and evaluation:

This project will be periodically mornitored by the Committee on Tungsten as per its policies and procedure. The result of the project work will be evaluated as per the Committee's evaluation system. Progress reports will be prepared at six-monthly intervals,and there will be a final report on the conclusion of the project.

J. Annexes:

Annex 1	Statistics for the export of tungsten concentrate by China between 1987- 1991
ANNEX 2	Inputs by China
ANNEX-B1	Inputs by Common Fund
ANNEX-B2	Budget for financing by Common Fund
ANNEX-B3	Budget for investment by China
ANNEX-B4	Number of days during which the new equipment would be in use
ANNEX-B5	Provisional work plan

ON BEHALF OF	NAME/TITLE	SIGNATURE	DATE
(THE ICB)	.....	.....	.....

The UNCTAD Committee on Tungsten hereby submits the following project proposals with its recommendation for financing through the Second Account of the Common Fund.

TITLE OF THE PROJECT: (C) Development of the [illegible] process for [illegible] of cemented carbide and its [illegible]

DURATION: Four yeeaps

LOCATION: Zhuzhou Cemented Carbide Ltd stry f[illegible] China

NATURE: This [illegible]ct is intended to improve the [illegible]rmance of cemented carbide, which is beneficial for the tungsten consuming countries to increase working efficiency and reduce processing cost.

TOTAL COST: USD [illegible],725,000
SDR 1,089,286 (Basis 1 SDR = USD 1.4)

FINANCING (AS GRANT)
SOUGHT FROM THE FUND: USD 1,300,000

COUNTERPART CONTRIBUTION
FROM CHINA: USD 225,000

PROJECT EXECUTING AGENCY: China National Nonferrous Metals Industry Corp.

ESTIMATED STARTING DATE: As soon as possible

A. Project description:

The final main use of tungsten is to produce cemented carbide. During its practical application of inserts and tips, there usually occurs early chipping or wear, because its toughness and wear resistance can not be well combined. For many years, every effort has been made to have a high performance cemented carbide with a good combination of wear resistance and toughness. Heat-treatment of cemented carbide is a simple and efficient way. It is found out that change in the composition of binding phase and structure by heat-treatment can increase toughness. In this sense, there is important practical significance in revealing the re-enforcing mechanism of cemented carbide by heat-treatment, investigating the optimum condition of heat-treatment, in developing new series of heat-treated cemented carbide with well combined properties, in widening its application scope, and in enhancing its ability to compete with other substitution materials.

The possibility of heat-treatment of cemented carbide was presented as early as in the 1940s. Such research was conducted in former Soviet Union, Sweden in the 1960s. In mid 1980s, China began to research on heat-treatment of WC-Co alloy for mining tools. It is shown by practical use that the occurance of chipping is obviously reduced with an increase in drilling efficiency and a decrease in drill and mining cost. However, further effort is still required to research on the heat-treatment of cutting inserts,drawing and forming dies, and wear resistant parts.

Main components of the project:

(i) Objectives:
The overall objective of this project is to improve the cemented carbide performance as a whole, to expand its application, and to fully utilize the tungsten resources.

(ii) The strategy and target beneficiaries:
The main target is to develop series of new heat-treated cemented carbide with better performance so as to expand its application field. The achievements report will be delivered free of charge to those interested member countries.

(iii) Expected situation at the completion of the project:
As a result, failure rate of the heat-treated non-brazed tools can be decreased by 50% with double service life.

(iv) Implementation arrarngement:
During the next month following the approval of this project, the Ministry of Foreign Economic Relations and Trade and China National Non-ferrous Metals Industry Corp. together with Zhuzhou Cemented Carbide Industry Co.and personnel concerned shall meet to finalize the task,objective and workplan .

Upon definition of the task, Zhuzhou Cemented Carbide Industry Co.

shall, within 3 months, complete organization and work out practical plan, optimize literature survey, determine process route, and conduct overseas technical exchange.

Detailed workplan and schedule are listed in the attachment.

B. Project justification:

(a) Economical and financial aspects:
Series of new heat-treated cemented carbide grades shall be developed wit double service life.Judging from the Chinese market, a 10-15% increase in economic return will be gained for one ton of heat-treated cemented carbide produced when the new grades are put into prodution.

With the improvement in the product property and durability,the user's tool cost shall be decreased, and working efficiency is increased, thus providing more choices for user's selection, bringing about an increase in both economic and social benefit for the user.

(b) Technical appraisal and feasibility:
The possibility for heat-treatment of cemented carbide was presented as early as 1940s.In recent years, many researchers have paid much attention to this subject. Investigation and experiments have been done in former Soviet Union, Sweden, Germany, SouthAfrica and China etc. especially in the former Soviet Union, great efforts were made systematically with establishment of heat-treatment process for a number of cemented carbide grades, and it was successfully applied into production.The heat-treated mining tool,punching die, heading die,anvil and other tools for use under shock load condition can exhibit better quality.

Researchers in Sweden, Germany and China gained a better understanding of phase transformation of Co phase by further investigation into the re-enforcement mechanism of heat-treating cemented carbide. All these previous work has shown practically and theoretically that there is a bright prospect and great potential for heat-treating cemented carbide. Our preliminary research indicated that the heat-treatment of cemented carbide can change the composition and structure of binding phase, leading to a significant improvement in the physical & mechanical properties (toughness in particular), to the end of increasing tool life.

The heat-treating research of cemented carbide is conducted in China in a unique way which is quite different from that of western countries and the former Soviet Union. Our initial research shows that the effect of heat-treatment is to adjust and control the dissolving & precipitation process of tungsten and carbon atoms in cobalt based solid solution, resulting in an increase in the solid solution concentration of tungsten and carbon , effectively preventing the occurrence of martensitic transformation in the cobalt phase and bringing about an obvious increase in the number of face-cubic cobalt, which is beneficial

to the improvement of cemented carbide.

(c) Environmental aspects:
There is no detrimental effect to the environment.

(d) Social and economic aspects:
This project shall contribute to the expansion of cemented carbide by improving its properties in all of the cemented carbide producers, and it is beneficial especially for the developing countries to improve the structural conditions in market enhancing the long-term competitiveness.

(e) Relevance to the CommonFund's objective,priorities and policy guidelines.
This project is to improve the product quality, enhancing working efficiency, and to expand its application field.

C. Objectives:

Objective 1.
Research on the heat-treatment condition for the > 8% Co cemented carbide;on the mechanism of Co phase re-enforcement and toughening of cemented carbide.

1.1 Output 1.
The TRS of heat-treated WC-Co and WC-TiC-TaC-Co(>8%) alloys shall be increased by 10%-30% with double durability.

1.1.1. Activity 1.
Upon approval of the project, Zhuzhou Cemented Carbide Industry Co. shall immediately finalize the task ,work out detailed objectives and execution plan.

1.1.2. Activity 2.
To conduct extensive literature survey , determine process route and conduct overseas technical exchange.

1.1.3. Activity 3.
The four-year R & D workplan shall be drawn out,covering the development of heat-treated cemented carbide, promotion and application and achievement evaluation.

1.1.4. Activity 4.
Establishment of a vacuum sintering----heat-treatment pilot laboratory via the purchase of furnace, installation and running-in.

1.1.5. Activity 5.
Research on the relation between the change in property and structure under different heat-treating condition.

1.1.6. Activity 6.
Research on different quenching method and its effect.

1.1.7. Activity 7.

Research on the critical quenching and cooling speed for the heat-treatment of cemented carbide with different composition and structure.

1.2. Output 2.
With the improvement in product properties, the heat-treated cemented carbides can be substituted for some cemented carbides with special properties, providing a wider range of choice for the user.

The increase in durability can reduce tool cost for the user, increase working efficiency, resulting in more economic return for the user.

1.2.1. Activity 1.
Optimization of the process parameters for heat-treatment of WC-Co systems.

1.2.2. Activity 2.
Research on the microstructure of heat-treated WC-Co systems.

1.2.3. Activity 3.
On-site performance test for heat-treated WC-Co systems.

1.2.4. Activity 4.
Research on the heat-treatment process for WC-TiC-(NbC.TaC)-Co systems.

2. Objective 2.
Research on the heat-treatment condition of < 8% Co cemented carbide; on the possibility of toughening low Co-containing cemented carbide and achievable degree of comercializing the heat-treated low Co-containing cemented carbides.

2.1. Output 1.
To determine the possibility of comercializing the heat-treated < 8% Co-containing cemented carbides, and present a evaluation report.

2.1.1. Activity 1.
Research on process parameters for heat-treatment.

2.1.2. Activity 2.
On-site comparative test for heat-treated cemented carbide .

2.1.3. Activity 3.
Research on the mechanism of heat-treatment process.

3. Objective 3.
Research on the failure characteristics of heat-treated cemented carbide tools in practical use in order to determine the limit of condition in application.

3.1. Output 1.
Failure rate of the heat-treated non-brazed cemented cabide tools can be decreased by 50% with double service life.

3.1.1. Activity 1.
Research on the influence of various brazing method and brazing condition that are detrimental to the heat-treament effect.

3.1.2. Activity 2.
Extensive on-site comparative test.

3.1.3. Activity 3.
Research on the failure characteristcs and fracture mechanism of the heat-treated cemented carbides by means of TEM and AEM etc.

D. Input.

The inputs required to carry out the project's activities as well as to obtain the specific outputs are given in Annex-C1.

E. Risk.

No risk.

F. The project budget.

This project requires financing of USD 1,300,000 from the Fund, see Annex-C2. Additionally, China will invest USD 225,000 to help complete the project, see Annex-C3.

For the number of days during which the new equipment (with investment from the Commmon Fund and China) would be in use, see Annex-C4.

G. Provisional work plan:

See Annex-C5

H. Project management.

Project Executing Agency: China National Non-ferrous Metals Industry Corp.

The sponsoring ICB is willing and able to assume responsibility as a Supervisory Body for the project without charge:

YES _____ NO ___

If not, give alternative proposal:

I. Project monotoring,reporting and evaluation:

This project will be periodically mornitored by the Committee on Tungsten as per its policies and procedures. The result of the project will be evaluated annually as per the Committee's evaluation system. Progress reports will be prepared at six-monthly intervals,there will be a final report on the conclusion of the project.

J. Annexes:

Annex 1	Statistics for the export of tungsten concentrate by China between 1987-1991
ANNEX 2	Input by China
ANNEX-C1	Inputs by the Common Fund
ANNEX-C2	Budget for financing by Common Fund
ANNEX-C3	Budget for investment by China
ANNEX-C4	Number of days during which the new equipment would be in use
ANNEX-C5	Provisional Work plan

ON BEHALF OF	NAME/TITLE	SIGNATURE	DATE
(THE ICB)	.....	.....	.....

ANNEX 1

In addition to improving the product quality, increasing working efficiency, reducing production cost and fully utilizing tungsten resources, the implementation of the three projects is also envisaged to rationally adjust the world tungsten market structure, to suitably control the amount of export of tungsten ore concentrate so as [illegible] being of benefit to the tungsten producing countries. The following table will show the efforts made by China to reduce the [illegible] of tungsten concentrate from 11905 tons in 1987 to 3127 tons in 1991. The reduction of tungsten concentrate quotation [illegible] helped [illegible] from [illegible] to around [illegible] many tungsten producing [illegible]

[illegible] tungsten resources, it takes only about 4% of the [illegible] (world annual trade volume is about 5500 tones) in terms of the end product--- cemented carbide, see table 2.

TABLE 1 Export of Tungsten Ore Concentrate by China Between 1987-1991
(Ton W Content)

Year	1987	1988	1989	1990	1991
Quantity	11905	14054	15914	8472	3127

TABLE 2 Export of cemented carbide by China between 1981--1991 (ton)

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Quantity	45	50	50	55	90	150	160	281	210	310	230

ANNEX 2

Inputs by China

List of existing equipment and laboratory instruments at Zhuzhou Cemented Carbide Industry Co. for carrying out the three projects' activities.

1	Small hydrogen reduction furnace, automatic push type	1
2	Small carburizing furnace, 80mm in diameter	1
3	Cylinder for ball mill, 8x1L	10
4	V-type mixer, 50L	1
5	High efficiency V-type mixer, 30L	1
6	Wet ball mill, 30L	1
7	Spray dryer ,10KG/h	1
8	Dorst automatic press, 15t	1
9	Single-shaft hydraulic press, 25t, 40t, 60t	1 each
10	Frame type press, 1000t	1
11	Hydraulic press with horizontal pressing, 100t	1
12	Push type sintering furnace (Mo wire)	1
13	GCA vaccum sintering furnace,400x400x1000	1
14	Hot press, 50t	1
15	Vaccum heat-treating furnace, 50KW, 1350 C	1
16	Vaccum tempering and annealing furnace,30KW,800 C	1
17	CVD and PCVD coating furnace	1 each
18	powder injection moulding machine, 200g	1
19	Pressure injection machine, 50g	1
20	CIP ,1200 mpa	1
21	HIP	1
22	Extrusion press, 200t	1
23	Spectophotometer, UV-260 (Japan)	1
24	Atomic adsorption spectophotometer , AA-670 (Japan)	1
25	Oscillograph polarograph	
26	High carbon analylizer	1
27	Pulse coulomb oxygen analylizer	1
28	Pulse heating chromatograph	1
29	sulphur analylizer , SA 2002L (Germany)	1
30	Nitrogen and oxygen analylizer,NOA 2003 (Germany)	1
31	carbon anaylizer , CA 200H (Germany)	1
32	Grating spectrograph, PGS-2 (Germany)	1
33	Direct-read optical spectrometer (imported)	1
34	DC plasma spectrometer,S-SV (USA)	1
35	Metallograph, NEOPHOT21 (Germany)	1
36	X-ray fluorescent/diffratometer PW140 41700	1
37	Electronic microscope ,JEM-2000EX (Japan)	1
38	Scanning electronic microscope ,ASM-SX (Japan)	1
39	Image analylizer QTM-720 (UK)	1
40	Universal material testing,AG-10 TA (Japan)	1
41	Fatigue tester, PWS-200	1
42	Elastic modulus tester	1
43	High temperature strength tester,	1
44	High temperature hardness tester	1
45	Small energy multi-shock tester	1
46	Wear tester, M-200	1

47	FSSS analylizer	1
48	BET analylizer	1
49	Particle size distribution analylizer	1
50	Particle nephometer	1
51	Coercive force meter	1
52	Magnetic satuation tester	1
53	Specific resistance meter	1
54	High frequency welding machine	1
55	Insert grinder	1
56	Tool grinder	1
57	Perimeter grinder	1
58	Plane grinder	1
59	Chamfer grinder	1
60	Dumpling machine	1

Value of the above existing Chinese equipment after depreciation is USD 4,050,000.

The total rental charge of the above equipment during the implementation of the three projects is USD 810,000, of which rental charges for project A is USD 100,000; for project B is USD 185,000; for project C is USD 225,000.

ANNEX-A1

A Inputs by Common Fund

	Description	Amount
1.	Equipment	
1.1	Low pressure HIP/vacuum sinteering furnace (1 set)	USD 705,000
1.2	Chromatographic micro-reaction tester (1 set)	USD 195,000
	Subtotal	USD 900,000
2.	Personnel salary	USD 105,000
3.	Administration	USD 15,000
4.	Official travel	
4.1	Overseas travel	USD 95,000
4.2	Domestic travel	USD 65,000
5.	Contracts and service	USD 57,000
6.	Miscellaeous	
6.1	Raw & subsidiary materials	USD 180,000
6.2	Testing & examination	USD 190,000
6.3	Maintenance	USD 20,000
6.4	Other	USD 23,000
7.	Contingency	USD 50,000
	Total	USD 1,700,000

B Inputs by China

1. For inputs of the existing Chinese equipment, see ANNEX 2 for project A,B and C. Rental charges for project A is USD 400,000.

2. Input of New equipment by China

2.1	50 KW DC plasma furnace (1 set)	USD 145,000
2.2	Reaction spray equipment (1 set)	USD 45,000
2.3	Energy dispersive (small angle) X-ray analyzer	USD 75,000
	Total:	265,000

ANNEX-A2

1. Project A's budget for financing by the Common Fund
Total: USD 1,700,000 Unit: USD

		Total	1st year	2nd year	3rd year	4th year	5th year
1	Personnel salary	105,000	18,500	19,500	21,000	22,500	23,500
2	Adminitration	15,000	2,600	2,800	3,000	3,200	3,400
3	Official travel						
3.1	Overseas travel	95,000	22,800	20,200	14,000	16,500	21,500
3.2	Domestic travel	65,000	14,100	11,900	13,000	11,800	14,200
4.	Contracts & service	57,000	12,400	10,100	10,700	11,600	12,200
5	Equipment	900,000	705,000	195,000	--	--	--
6	Miscellaneous						
6.1	Raw & subsidiary materials	180,000	37,500	39,500	36,500	35,500	31,000
6.2	Testing etc.	190,000	37,300	40,500	39,000	38,100	35,100
6.3	Maintenance	20,000	3,100	3,500	4,000	4,600	4,800
6.4	Other	23,000	3,800	4,300	4,900	5,300	4,700
7.	Continggency	50,000	9,000	9,800	10,000	10,900	10,300
	Total	1,700,000	866,100	357,100	156,100	160,000	160,700

ANNEX-A3

Budget for investment by China for development of project A

	Total	1st year	2nd	3rd	4th	5th
Equipment rent	400,000	82,000	88,000	83,000	77,000	70,000
New equipmet	265,000	145,000	45,000	75,000	--	--
Total	665,000	227,000	133,000	158,000	77,000	70,000

ANNEX-A4

Number of days during which the new equipment would be in use for execution of project A.

	Description	Predicted number of days used annually				
		1st year	2nd	3rd	4th	5th
1.	Low pressure HIP/ sintering furnace	250	300	240	200	150
2.	Chromotographic micro-reaction tester	110	140	160	180	130
3.	50 KW DC plasma furnace	300	310	280	260	210
4.	Reaction spray equipment	270	265	255	230	190
5.	Energy dispersive (small angle) X-ray analyzer	135	155	145	115	105

ANNEX-A5

Provisional Work plan

content	1st year	2nd year	3rd year	4th year	5th year
1. Preparation of ultra fine WC powder					
1.1 Selection of raw material	----------				
1.2 Setting up plasma lab		----------			
1.3 Preparation of ultra fine powder by plasma				----------	
2. Passivation and storing technique for ultra fine powder				----------	
3. Research on catalystic WC			----------		
4. Development of fine-grained cemented carbide				----------	----------
4.1 selection of equipment		----------			
4.2 Compaction method, selection of equipment		----------			
4.3 Optimizing sintering process		----------			
5. Analytical and testing					
5.1 Determination of grain size		----------			
5.2 Research on grain size		----------			

ANNEX-B1

A. Inputs by the Common Fund

	Description	Amount
1.	Equipment	
1.1	Energy spectrometer (1 set)	USD 210,000
1.2	Wire cutting machine (1 set)	USD 240,000
	Subtotal:	USD 450,000
2.	Personnel salary	USD 60,000
3.	Administration	USD 17,500
4.	Official travel	
4.1	Overseas travel	USD 49,000
4.2	Domestic travel	USD 35,000
5	Contracts & service	USD 25,000
6.	Miscellaneous	
6.1	Raw & subsidiary materials	USD 76,000
6.2	Testing & examination	USD 94,000
6.3	Maintenance	USD 24,000
6.4	Other	USD 11,500
7.	Contingency	USD 18,000
		USD 860,000

B. Inputs by China

1. For inputs of the existing Chinese equipment, see ANNEX 2. The rental charges for project B is USD 185,000.
2. Input of new equipment

2.1	50 KW vacuum sintering furnace	USD 44,500
2.2	Small vacuum carburizing furnace	USD 34,000
2.3	Vacuum induction smelting furnace	USD 41,000
2.4	Wettability analyzer (computer controlled)	USD 25,500
	Total	USD 145,000

ANNEX-B2

Project B's budget for financing by the Common Fund
Total: USD 860,000 Unit: USD

	Total	1st year	2nd	3rd	4th
1. Personnel salary	60,000	13,500	14,600	15,500	16,400
2. Administration	17,500	3,900	4,100	4,400	5,100
3. Official travel					
3.1 Overseas travel	49,000	13,200	10,800	11,300	13,700
3.2 Domestic travel	35,000	11,000	7,000	6,500	10,500
4. Contracts & service	25,000	7,500	5,000	5,800	6,700
5. Equipment	450,000	240,000	210,000	--	--
6. Miscellaneous					
6.1 Raw & subsidiary materials	76,000	17,800	22,400	18,700	17,100
6.2 Testing etc.	94,000	22,300	23,400	21,300	27,000
6.3 Maintenance	24,000	5,500	6,000	6,100	6,400
6.4 Other	11,500	2,500	2,000	3,300	3,700
7. Contingency	18,000	6,200	5,200	4,500	2,100
Total	860,000	343,400	310,500	97,400	108,700

ANNEX-B3

Budget for investment by China for development of project B

	Total	1st year	2nd	3rd	4th
Equipment rent	185,000	51,000	52,000	47,500	34,500
New equipment	145,000	41,000	78,500	25,500	--
Total	330,000	92,000	130,500	73,000	34,500

ANNEX-B4

Number of days during which the new equipment would be in use for execution of project B.

	Description	Predicted number of days used annually			
		1st year	2nd	3rd	4th
1.	Energy spectrometer	90	100	118	125
2.	wire cutting machine	225	238	198	215
3.	50 KW vacuum sintering furnace	320	325	315	305
4.	Small vacuum carburizing furnace	218	228	196	185
5.	Vacuum induction smelting furnace	53	84	76	69
6.	Wettability analyzer	35	48	37	34

ANNEX-B5

Provisional Work plan

content	1st year				2nd year				3rd year				4th year			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Addition of rear earth																
1.1 Proper kind of addition	----------															
1.2 Addition method		--------														
1.3 Addition amount		----------														
2. Microstructure and wettability			----------													
3. Pilot test, optimization of parameter				----------												
4. Complete grade designing			----------													
4.1 Small batch production					----------											
4.2 On-site test							----------									
5. Perfection of process										----------						
6. Promote application											----------					

ANNEX-C1

A. Inputs by the Common Fund

	Description	Amount
1.	Equipment	
1.1	Vacuum sintering-quenching furnace (1 set)	USD 100,000
1.2	Electronic prob (1 set)	USD 500,000
	Subtotal:	USD 600,000
2.	Personnel salary	USD 80,000
3.	Administration	USD 16,000
4.	Official travel	
4.1	Overseas travel	USD 72,000
4.2	Domestic travel	USD 48,000
5.	Contracts & service	USD 53,000
6.	Miscellaneous	
6.1	Raw & subsidiary materials	USD 160,000
6.2	Testing etc.	USD 170,000
6.3	Maintenance	USD 28,000
6.4	Other	USD 26,000
7.	Contingency	USD 47,000
	Total	USD 1,300,000

B. Inputs by China

For inputs of the existing Chinese equipment, see ANNEX 2 for project A,B and C. The rental charges for project C is USD 225,000.

ANNEX-C2

Project C's budget for financing by the Common Fund
Total: USD 1,300,000 Unit:USD

		Total	1st year	2nd	3rd	4th
1.	Personnel salary	80,000	18,400	19,400	20,500	21,700
2.	Administration	16,000	3,300	3,700	4,250	4,750
3.	Official travel					
3.1	Overseas travel	72,000	20,400	15,600	17,000	19,000
3.2	Domestic travel	48,000	12,500	11,400	12,000	12,100
4.	Contracts & service	53,000	13,400	13,800	12,700	13,100
5.	Equipment	600,000	100,000	500,000	--	--
6.	Miscellaneous					
6.1	Raw & subsidiary Materials	160,000	38,000	44,000	42,000	36,000
6.2	Testing etc.	170,000	43,000	46,000	41,000	40,000
6.3	Maintenance	28,000	5,900	6,600	7,400	8,100
6.4	Other	26,000	6,300	6,900	7,200	5,600
7.	Contingency	47,000	10,200	11,700	12,300	12,800
	Total	1,300,000	271,400	679,100	176,350	173,150

ANNEX-C3

Budget for investment by China for development of project C

	Total	1st year	2nd	3rd	4th
Equipment rent	225,000	58,000	59,000	55,500	52,500
New equipment	---	---	----	---	---

ANNEX-C4

Number of days during which the new equipment would be in use for execution of project C.

Description	Predicted number of days used annually			
	1st year	2nd	3rd	4th
1. Vacuum sintering-quenching furnace	308	328	317	314
2. Electronic prob	87	93	91	88

ANNEX-C5

Provisional Work plan

Content	1st year						2nd year						3rd year						4th year					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1.WC-Co systems																								
1.1 Optimization of process parameters																								
1.1.1 Quenching and tempering							----																	
1.1.2 Selection of quenching method	----																							
1.1.3 Minimum speed for strengthening and toughening													----											
1.2 Research on microstructure of heat-treated alloys							----																	
1.3 On-site test													----											
2. WC-TiC-(TaC-NbC)-Co																								
2.1 Research on heat-treatment process													----											